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IMerit: Machine Learning for Women's Empowerment, an Interim Report

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Machine Learning for Women's Empowerment - Interim Report

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“Little by little, we're giving sight to the machines. First, we teach them to see. Then, they help us to see better. For the first time, human eyes wont be the only ones pondering and exploring our world.”

-Dr. Fei Fei Li, Stanford University

Abstract

This interim report will serve as the basis for a senior thesis that will be published in May 2016. This report will recommend strategies for iMerit Technology Services to benefit from machine learning. It will explain the potential of machine learning by using iMerit as an example of a successful social enterprise engaging in computer vision data processing. This paper presents research activities including interviews and observation of iMerit’s employees as evidence of their capability, self-efficacy, and ability to acquire skill over time, and thus show their ideal position in the delivery chain of machine learning technologies. iMerit is uniquely suited to the challenge of creating accurate data sets for computer vision software. By hiring and training marginalized youth and women, iMerit ensures that sensitive data is protected, a positive and familial work environment is sustained, and lastly, iMerit is able to form positive technological work habits from the beginning of its operator’s work careers.

During interviews, iMerit’s Metiabruz operators reported that they felt a sense of pride and self-confidence from working on projects that involved high technology. The operators displayed a high aptitude for critical thinking compared to other workers in their same demographic. This critical thinking manifested itself through advanced technological habits such as using hotkeys to perform tasks on a computer. When surveyed, iMerit’s operators displayed a self-efficacy that was consistently above average, with the highest scores correlating to a belief in personal achievement.

On the basis of these key findings, this report recommends that iMerit implement additional machine learning training for its operators. The report also suggests that iMerit implement its own data processing software platform. Hiring a subject-matter expert in the field of machine learning could be very beneficial for iMerit to strengthen its sales and marketing strategy. iMerit may find advantages in further testing its operators using self-efficacy as a benchmark. In this way iMerit can evaluate the degree to which new training is effective in the empowerment of its workers.

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"It has been a great experience in life. I was scared about my future until I came to iMerit. I have much more confidence walking down the street now."

-iMerit Operator on working at iMerit

What is Machine Learning?

Machine learning is a field of growing importance in technology. Despite this interest, a succinct definition of machine learning is difficult to find. Machine learning is a subsection of the technological fields of artificial intelligence and statistics.[1] In its most basic form, it is a way of gathering meaning from data taken of the observable world. Machine learning has become very popular due to its potential to be used in a multitude of different fields beyond just technology. Machine learning processes have already been applied to many high profile technologies such as Facebook's automatic image tagging mechanism on uploaded pictures or Google's self-driving car. The market for products that use machine learning is growing exponentially. Oculus, a company whose primary technology relies heavily on machine learning, recently received a valuation of two billion dollars and was promptly bought by Facebook. This is just an example of how important machine learning is from a business perspective.

Machine learning can be broken down into two basic fields: supervised learning, and unsupervised learning. Unsupervised learning consists of providing a computer with a large set of data in order to have the computer construct a pattern from within that data. Supervised learning involves teaching a computer to make decisions based on a "training set" or set of data that has been curated by a human being to show "correct" answers. This report will focus on supervised learning as this type of machine learning process requires human interaction, and therefore requires services like those that iMerit provides.

[1] Szeliski, Richard. Computer Vision: Algorithms and Applications. London: Springer, 2011. Kindle Edition.

Computer Vision

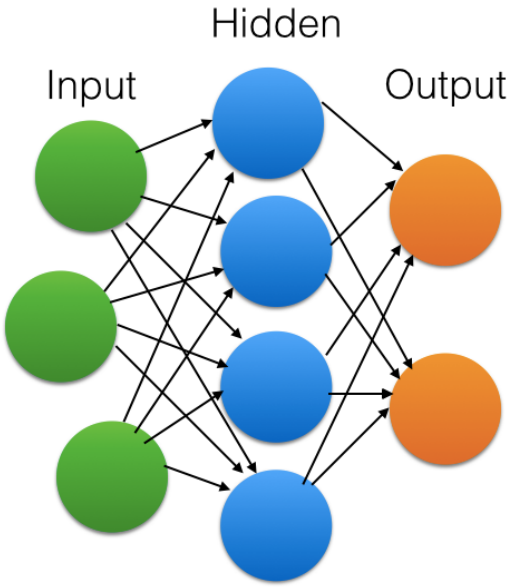
Many of iMerit's machine learning projects have involved image tagging for computer vision software, therefore it is important to define computer vision and the challenges that are necessary to overcome in order to teach a computer to see. The human eye is a complex organ, however, the truly difficult part of the process of teaching a computer to see is modeling how the human brain interprets the images that the eye presents it with. The human brain has evolved to take mere milliseconds to make meaning from sensory data. The subsection of machine learning called computer vision seeks to implement this sort of intelligent perception in computers.

An example of a tagged image.

Computer vision is a type of supervised machine learning. Training sets are used to teach computers to recognize certain objects or patterns. These training sets are usually images that have been pre-tagged using a human operator, much like the butterfly example above. Facial and motion recognition technologies would fall under this subsection of machine learning. Some examples of the uses of computer vision technologies are optical character recognition, machine inspection, retail, 3D model building, medical imaging, automotive safety, motion capture, match-moving, surveillance, and biometrics(such as fingerprint recognition). An example of an application of computer vision software that is very well known in popular culture is the Xbox Kinect, a gaming camera with the capability to recognize a person's face. This software would never have been created without the help of human workers tagging eyes, noses, mouths, and other distinguishing features on thousands of images of faces.[2]

[2]Szeliski, Richard (2013-09-10). Computer Vision (Texts in Computer Science) (Page 12). Springer. Kindle Edition.

History of Machine Learning



The structure of a neural network

Machine learning is built upon its many related fields including statistics, artificial intelligence, and data mining. Artificial intelligence and machine learning have long captured the minds of futurists and technologists, with countless books of scientific fiction being written on the subject. Eventually, machine learning as a field became less the subject of mathematical speculation and more of practical application to real world problems. With the advent of open source technologies, machine learning has become accessible to programmers around the world. Similarly, in the spirit of open source collaboration, massive data sets are being uploaded to the internet for use by anyone with an interest in machine learning. This has helped many students and professions begin their journey into the field of machine learning.

The field of computer vision has become more sophisticated due to developments in computer graphics and the subsequent marriage of these two fields. The latest trend in the field of computer vision is without a doubt, virtual reality. Virtual reality has exploded in popularity. Almost all major technology companies have begun to design and announce their own virtual reality products. Gaming and wearable technology have recently created a resurgence of interest in this field.

iMerit Background

iMerit is a social enterprise which delivers digital data services while also impacting the poor and marginalized youth and women of India. iMerit's non-profit sister organization, Anudip, trains underprivileged women and youth. iMerit then employs these women — and others — as operators. As operators, iMerit's employees work on a variety of different tasks. From labeling and tagging images of eyes to coding XML documents, these operators work very diligently resulting in a product that is delivered with high accuracy and throughput.

iMerit's use of Machine Learning

Image tagging is a necessary part of the supervised learning process. Data is cleaned, sorted, tagged, and marked up by iMerit workers in a way that is understandable by a computer. This is usually achieved by using a software application that is packaged by iMerit's client along with the data to be tagged.

Neural Networks are a regression method by which information from tagged images such as those created by iMerit operators are turned into software. They work similarly to neurons in the human brain, hence the name "Neural Networks". In order to solve the issues inherit with processing massive amounts of data through algorithms like linear regression, computer programmers have created the neural network system. A neural network consists of three different types of nodes or the basic data units of the system. These nodes contain both information as well as links to other nodes. The hidden nodes represent the strength of an association, much like the associations neurons make within our brains. By presenting a system like this with a tagged input, "correct" associations are numerically strengthened and the computer is able to learn.[3]

According to prominent machine learning professor Fei Fei Li of Stanford University, the applications of this form of using neural networks for computer vision software reach far beyond just the gaming industry and can ultimately affect every part of our lives. Education can be completely reimagined using computer vision software. Computers will be able to scan thousands of medical images and spot anomalies instantly. The quality of our lives can vastly improved by the proliferation of machine learning into a breadth of different industries.

iMerit in the Computer Vision Product Delivery Chain

iMerit provides services which are an integral part of the machine learning software creation process. One of the most important parts of turning a machine learning concept into a reality is the curation and cleaning of raw data. Companies that require this service send their data, usually in the form of CSV files to iMerit to be cleaned, tagged, and organized. iMerit's operators use software to tag images with "correct" answers. These datasets are then returned to the company for them to process through their own software.

How is iMerit best suited to engage in this process?

iMerit is uniquely suited to the challenge of creating accurate data sets for computer vision software. By hiring and training marginalized youth and women, they are able to ensure that:

Sensitive data is protected

[3] Bhadeshia, H. K. Neural Networks. Vol. 39. Ann Arbor, MI: IEEE Neural Networks Council, 1990. Ser. 10. ISIJ. Web.

Companies outsource their data services to iMerit because this information could not be released to crowdsourcing platforms that have a cursory screening process. iMerit's workers are properly vetted from the beginning and are continually monitored to make sure that they deliver a high-quality product. Many of iMerit's workers do not usually have access to computers outside of their work environment, therefore they are less likely to share sensitive information over the internet.

Close cultural ties foster a positive and focused working atmosphere

iMerit's Metiabruz operators share a very strong cultural bond due to their backgrounds. While observing Metiabruz operators in their work environment, I found them to work in a collaborative yet focused manner, finding strength and motivation in one another.

iMerit is able to form positive tech habits from the beginning of these women's careers

iMerit is able to instill their operators with good technological habits from the beginning. Other workers who have had contact with technology may have lingering technological habits that spill over from their personal life to their work life, such as checking personal accounts while at work or never rebooting a laptop. iMerit has the opportunity to shape the way their employees interact and care for technology from the beginning of the employee's career.

Profile of Current Computer Vision Economy

Three of the largest companies in the tech field have invested in or acquired some form of computer vision software. Microsoft, Google, and Facebook all have up and coming computer vision products which are undergoing beta testing at this moment and will soon become commercially available.

Microsoft

Microsoft Hololens is a virtual reality tool that uses computer vision to simulate holographic interactions with the world around its user. When wearing the Hololens the user is able to engage with their immediate surroundings in new and exciting ways, including interactive instruction guides as well as games. Microsoft CEO Satya Nadella has said on the topic of the hololens, “if you’re an industrial designer and use AutoCAD or Maya on HoloLens, there’s no going back. You literally see the output of what you’re designing right next to you. The same goes for architects. Those (applications) are easy to imagine.” Microsoft is looking beyond just the gaming applications of its virtual reality project.

Google

Image from google.com

Google has created a virtual reality product that truly stands apart from its competitors. The product is Google Cardboard. While its competitors price in at $350 (Oculus Rift dev kit) and $3,000 (Microsoft Hololens dev kit), Google Cardboard costs a fraction of those prices at $23.95. By producing dev kits that are this inexpensive, Google is able to insure that a multitude of new developers will be able to afford and use their product, increasing both the depth and breadth of software that will eventually be developed for Google.

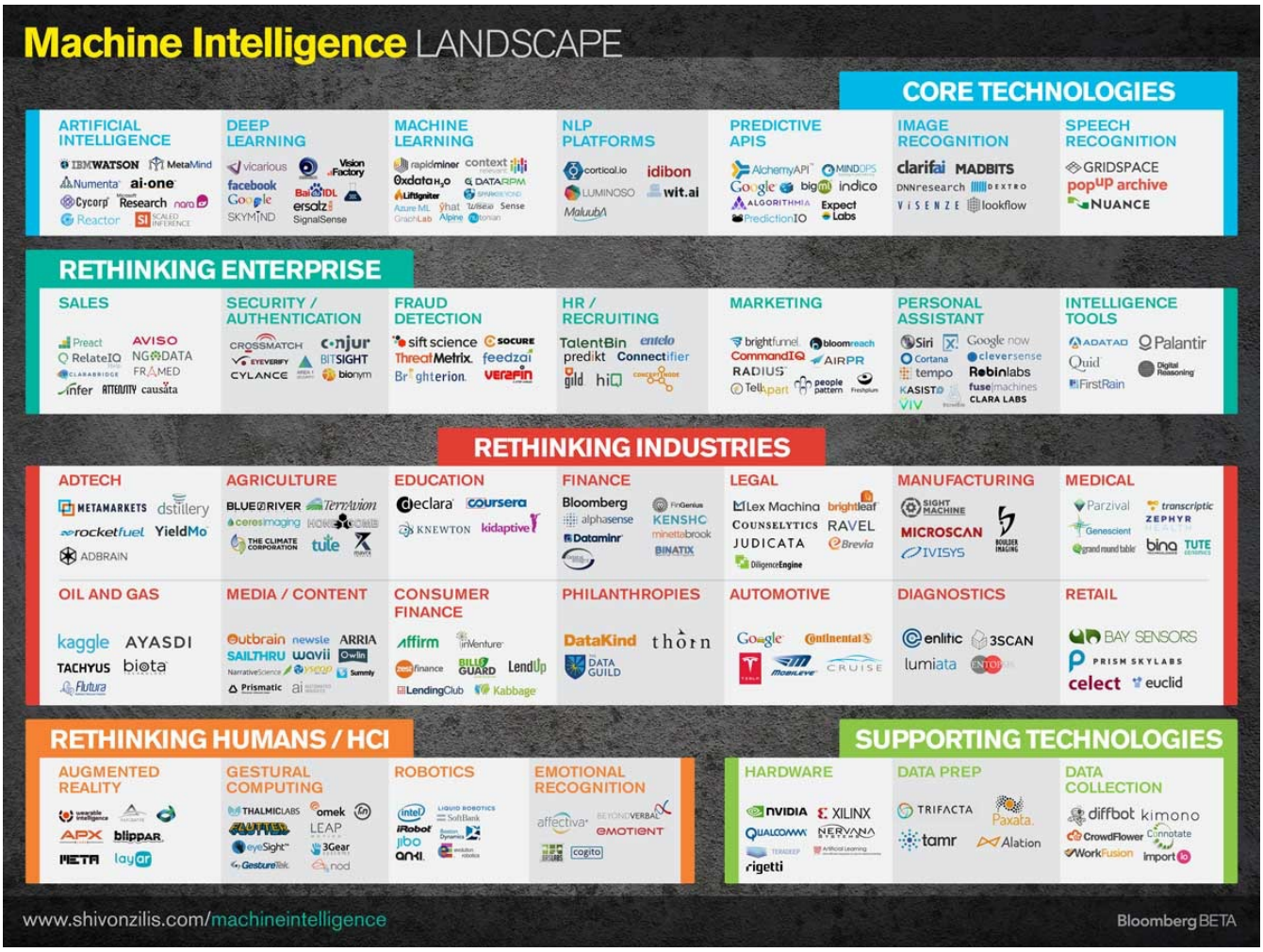
Facebook

In March 2014, Facebook acquired Oculus VR, a company dedicated to reimagining computer gaming through virtual reality.[4] While the Oculus VR’s preliminary marketing has mostly touted its ability to transport the user to his or her favorite video game, more and more developers are

[4] Constantine, Josh. "Facebook’s $2 Billion Acquisition Of Oculus Closes, Now Official." TechCrunch. N.p., n.d. Web.

buying development kits in order to develop new and exciting software that exceeds the boundaries. The current iteration of the Oculus development kit (2.0) is completely sold out.

Not only have these large software companies been investing in machine learning, but startup companies are bringing machine learning discoveries to the consumer. Angel.co, a website dedicated to helping investors find startups companies, recently registered over 843 startup companies dedicated to producing machine learning technology.[5] Below is an image that represents just a sample of emerging companies in this field.



Shivon Zilis, Machine Intelligence Landscape

[5] "AngelList." AngelList. N.p., n.d. Web. 2015.

Data Methodology

My research approach draws from Designing for the Digital Age by Kim Goodwin, which presents a clear methodology to understanding the users and different use cases of a potential software.[6]

Semi-structured Interviews

I conducted two rounds of semi-structured interviews with eight employees each to better understand the daily workflow of iMerit's operators as well as their understanding of machine learning. I relied on my faculty research mentor, Dr.Natalie Linnell, to craft an interview methodology that would be able to bridge the cultural and language boundaries between myself and the operators.

Sample Interview Structure

This interview structure is defined in chapter 8 of the book Designing for the Digital Age. Below is a sample script I used in order to conduct interviews in a structured and organized manner.

- **Introductions: who we are, why we're here, and what the next hour will be like**

Hello, my name is Chris, and I want to begin today by telling you a little bit about this project. We are Santa Clara University students working here at iMerit to research the company's involvement in machine learning. We want to see your opinions and ideas on machine learning and determine whether or not iMerit would benefit from incorporating an understanding of machine learning into its training methods.

We want to begin by learning more about you and your place within iMerit. We would then love for you to walk us through your current project and explain it to us. We then have some materials we'd like to show you about machine learning and record your responses to these materials.

Firstly, are you comfortable being audio recorded? Are you comfortable being photographed? Ok, let's begin.

We want to make sure you understand that any responses you make will have identifying information removed before they are shared with your supervisors.

- **Demographic Questions**

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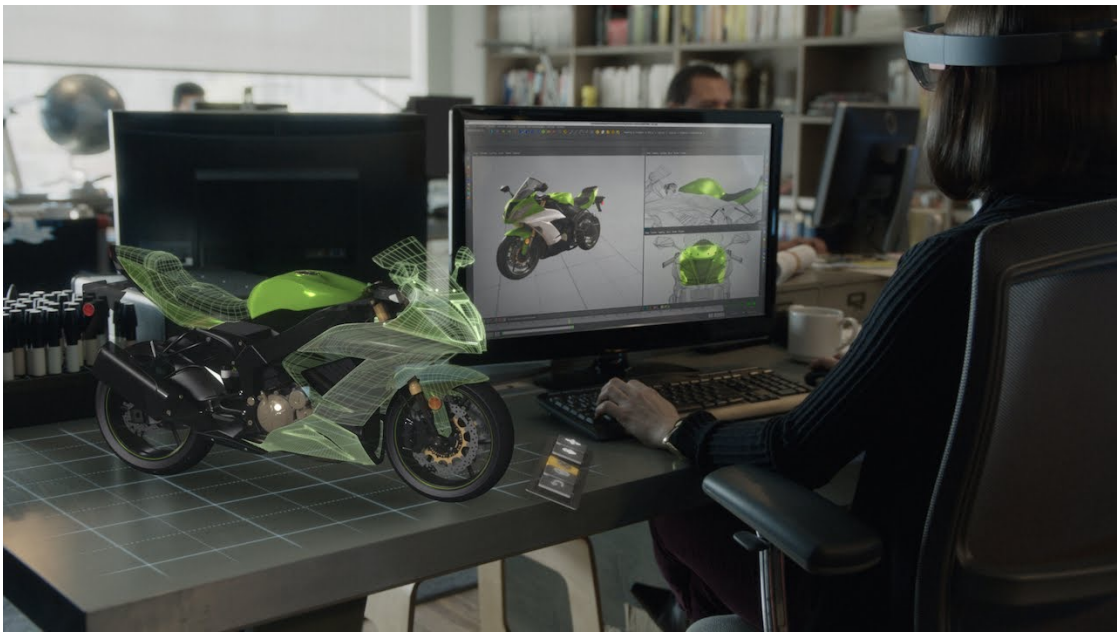
[6] Goodwin, Kim (2011-03-25). Designing for the Digital Age: How to Create Human-Centered Products and Services (p. 35). Wiley. Kindle Edition.

    - Name?
    - Age?
    - How did you find out about iMerit?
    - How long have you been working at iMerit?
- **overview question: broad topic about major activities and flow**
    - What do you know about machine learning?
    - How many Machine Learning projects have you worked on?
    - Could you describe one of the projects?
    - What were the most challenging parts of the project?
- **Demo of activities**
- **Ask operators for a guided walkthrough of the project they are working on.**
    - If they hesitate to talk about any certain aspect of project, ask them to go in depth about that part of the project or walkthrough
- **Looking for gaps: recap of activities covered so far and a request to fill in anything not mentioned so far**
- **Any extra questions about the project**
- **Details as needed: other topics you need to cover**
    - What was your reaction to this new project?
    - Any follow up to workflow issues operator described
- **Grand tour: a guided walk through of the usage environment**
    - For this part of the interview I showed the interviewee a video about a computer vision product, Microsoft Hololens, and then observed and recorded their reactions. The video I chose to show the operators was a video of Microsoft's Hololens product[7]

[7] https://www.youtube.com/watch?v=aThCr0PsyuA



Still from youtube video, Microsoft HoloLens - Transform your world with holograms

- **Follow up questions to video**
    - How does this new information make you feel? Interested, excited, any change in demeanor?
    - Are you interested in learning more about machine learning?
- **Self-efficacy test**
    - The interviewees were given a ten question self-efficacy survey written in their native language, Urdu, and were asked to circle an answers between one and four to each individual question
- **Mouse accuracy test**
    - During this portion of the interview I directed the interviewees to a website where they were prompted to test their typing skills.[8]
- **Leading questions: the magic solution question**
    - If you had a magic tool to make your job easier, could you describe it? This question is meant to be a last resort to locating some of the pain points in the operators everyday workflow that could be fixed through training
    -

[8] Waalboer, Juerd. "Typing Speed Test - Online Typing Test." Online Typing Test. N.p., n.d. Web. 11 Nov. 2015.

Observations

Observing iMerit's operators in their day to day workflow was one of the most important aspects of our research. During this observational period I took notes using a pen and paper, rather than with my computer, in order to respect the operators while they worked. During this observational period my main goal was to become more familiar with iMerit's operator workflow, and with the tools they used throughout their day to day activities. These observations led me to an assessment of all the tools that iMerit operators used.

Assessment of Workflow Tools

In order to get a better understanding of iMerit's workflow I assessed the different software suites the operators used on the basis of nine different usability metrics known collectively as a User Task Analysis. These metrics are explained in detail below.

Learnability:

Learnability refers to the ease with which a user is able to fully understand the features of a software.

UI design:

UI design is integral to the success of a software's usability. A poor design can lead users to become frustrated with the software without fully understanding why. It can also make performing tasks more difficult on the software.

Preciseness:

Preciseness defines how prone to errors a specific task is. If a task is highly prone to errors then it affects the overall usability of the system as users can become easily confused and sidetracked.

Functionality:

Functionality is at the core of any software and defines the range of different operations that a software is able to perform for the user.

Fault Tolerance:

Users often make mistakes when trying to use a piece of software. Ultimately these users may fail to "correctly" use the software for a multitude of different reasons, not just inexperience with

a computer. Software should be made with this in mind, so as to not unfairly punish a user for making a mistake.

Memorability:

Memorability refers to how easy it is for user to remember how to complete tasks on the application. Memorability is especially important for software used by iMerit's operators as they often have to complete many instances of the same sort of task.

Affordance:

Interactive elements can be helpful for the user to accomplish a task on the software system. However, if these interactive elements are confusing it can affect the whole system's usability.

Quality Assurance:

Making sure that every step of the task is up to a certain degree of quality.

Enjoyment:

Does performing tasks on the system give the user some sort of pleasure? Enjoyable tasks make it more likely for users to continue returning to the software and increase the quality of their time spent on the platform.

Platforms

Merit operators spend a high percentage of their time working on tasks on licensed platforms, therefore it was crucial to get a better understanding of the usability and potential pain points of these platforms. All platforms observed scored high on the user task analysis, however it is important to not that many of the platforms had difficulties with both affordance and fault tolerance. These elements are key components of a micro-tasking platform and should be considered highly important. The platforms that the operators use can serve as models for an integrative data processing software platform. To keep workers engaged and productive, the usability metrics specified earlier should be considered in the design process of a new technology platform.

Self-efficacy

The self-efficacy test can be used as a tool to measure the general empowerment of iMerit's workers. I conducted a descriptive study of iMerit's operators using this quantifier in order to better understand the effect that working at iMerit had on these operators. Self-efficacy refers to

an individual's belief in his or her capacity to execute behaviors necessary to produce specific performance attainments.[9]

Many studies have been done on both students and employees in order to determine the main factors that influence an individual's self-efficacy. The following have been identified as significantly important: experience or "enactive attainment", modeling or "vicarious experience", social persuasion, and other physiological factors. The following ten questions are part of the GSE or Generalized Self-Efficacy Scale and were included on the survey administered to iMerit's Metiabruz operators. The survey questions were presented in Urdu, the language that these operators were most familiar with in order to increase their understanding of the source material. The questions were as follows:

I can always manage to solve difficult problems if I try hard enough.

If someone opposes me; I can find means and ways to get what I want.

It is easy for me to stick to my aims and accomplish my goals.

I am confident that I could deal efficiently with unexpected events.

Thanks to my resourcefulness, I know how to handle unforeseen situations.

I can solve most problems if I invest the necessary effort.

I can remain calm when facing difficulties because I can rely on my coping abilities.

When I am confronted with a problem, I can usually find several solutions.

If I am in trouble I usually think of something to do.

No matter what comes my way, I'm usually able to handle it.

In response to these aforementioned questions, the operators were asked to circle one of four answers:

1 = Not at all true

2 = Hardly true

3 = Moderately true

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[9] Bandura, 1977, 1986, 1997,

4 = Exactly true

Data Presentation

Quantitative Testing

The operators' average typing speed score was 117.625 characters per minute. Of 17,973,340 people tested using the exact same test, the median score was 186 CPM.[10] One hypothesis for the difference between the operators' scores and the median could be that the words they are asked to write on the test are written in English as well as their unfamiliarity with the tool.

Self-Efficacy Breakdown by question:

I can always manage to solve difficult problems if I try hard enough: **3.25/4**

If someone opposes me; I can find means and ways to get what I want: **2.125/4**

It is easy for me to stick to my aims and accomplish my goals: **3.375/4**

I am confident that I could deal efficiently with unexpected events: **2.75/4**

Thanks to my resourcefulness, I know how to handle unforeseen situations: **2.875/4**

I can solve most problems if I invest the necessary effort: **3.125/4**

I can remain calm when facing difficulties because I can rely on my coping abilities: **3.125/4**

When I am confronted with a problem, I can usually find several solutions: **3/4**

If I am in trouble I usually think of something to do: **3/4**

No matter what comes my way, I'm usually able to handle it: **2.5/4**

Average total self-efficacy: 28.875/40

Observational Evidence of Unique Tech Habits:

During my observation of iMerit operators, I found the following behaviors to be significant to an analysis of the operators' behavioral traits. iMerit's operators had an atypical way of interacting with technology as a result of iMerit's training. The following are some examples of behaviors that I witnessed:

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[10] Waalboer, Juerd. "Typing Speed Test - Online Typing Test." Online Typing Test. N.p., n.d. Web. 11 Nov. 2015.

- operators often googled names that appear in documents
- operators often highlighted while reading to aid in reading pdf documents
- operators read at least 15 words per second or more, sometimes quickly scanning whole paragraphs
- operators often use find and replace to locate specific words (CMD+F)
- as well as windows cmd (WINDOWS+R)
- operators often use shortcuts to switch between pages (ALT+TAB)
- operators often copy important information into a google spreadsheet, then use this spreadsheet to copy information and input it into fields
- operators often use Skype to communicate and collaborate with other workers
- operators often send their information to one another to check
- operators use google to verify the content of the tasks that they don't initially understand
- operators will restart a computer if it freezes

Findings and Discussion

iMerit's operators displayed a self-efficacy that was consistently above average (2.5/5). When observing the nature of these questions, it appears that a correlation exists between their perceived scores and specific types of questions. For example, questions about the operator's personal ability such as "I can always manage to solve difficult problems if I try hard enough" elicited self-efficacy scores that were notably higher than those which involved situations in which the operator was forced to interact with others. In fact, the lowest average score of all ten of the questions, 2.1 out of 4, resulted from the question, "If someone opposes me; I can find means and ways to get what I want." One potential reason for this correlation could be the operators' backgrounds. Approximately half of the women I interviewed self-reported that they did not interact with coworkers outside of work. Many of these women did not have any formal education apart from what iMerit has provided them, therefore many may feel uncomfortable or not know how to self-advocate or challenge authority in the workplace.

As a result of my research, I believe that iMerit operators could benefit greatly from further enhanced training about the machine learning processes in which they engage. Many of the operators I interviewed responded very excitedly and enthusiastically about the work in which they were engaged. In fact, the majority of the operators I interviewed responded very positively when prompted whether or not they would be interested in learning more about machine learning. When I asked an operator, “How do you feel when you finish a task?” She replied, “Great! I achieve target every time and feel great.” Finishing tasks brought a sense of accomplishment and joy to this operator. I also believe that this inclusive training will have a positive impact on the operators’ productivity. During my interviews I showed a video of a demo of the Microsoft Hololens to an operator and asked her if she would like to learn more about machine learning. In response she stated, “Yes I would really like to. Wow, I work really hard now. I can say when I began I had no idea.” It appears that many of the operators feel a sense of pride and self-confidence that stems from working on projects that involve high technology.

iMerit’s Metiabruz operators have displayed a very high aptitude for critical thinking compared to other workers in their demographic. Although we cannot be sure without doing a broad scale study of women in the same demographic, the operator’s critical thinking habits appear to be a result of their training. One way their critical thinking manifested itself was through the operators’ technological habits. As a result of iMerit’s current training, iMerit’s operators have developed positive and unique technological habits. As anecdotal evidence, I even witnessed one of Metiabruz’s operators troubleshooting a computer that had frozen. iMerit’s operators have also developed a very collaborative working style. They would often collaborate over Skype in order to help each other when they encountered a difficult problem. This shows that they have the ability to solve complex problems.

Conclusion

iMerit has positioned itself as a leader in the field of dataset creation. It is a stellar example of a social enterprise that uses machine learning to empower its workers and create a positive social impact. On the basis of my research, here are several recommendations for iMerit to continue its great work and transition to working primarily in the field of machine learning dataset creation. These recommendations will be explained further in the senior thesis that is to be completed in May 2016.

Recommendations

Addition of machine learning training for operators

iMerit operators have expressed interest in learning more about the end product of the supervised machine learning tasks in which they engage. If they receive this training it could increase their self-efficacy and productivity. This training should be visual in nature in order help the operators' understanding of machine learning. A detailed explanation of the content of this training module will be included with the senior thesis. iMerit may also want to consider hiring a subject-matter expert in the field of computer vision as either a consultant or full-time employee, iMerit could have an enhanced insight into the machine learning business sector and be able to assist in the implementation of the employee training modules.

Implement a unified internal software platform

By creating their own software platform, iMerit will be able to clean and track their client's data in an efficient and standardized way. iMerit will also be able to track internal metrics regarding worker productivity.

Further test iMerit operators using self-efficacy as a benchmark

iMerit could benefit by measuring the self-efficacy of new hires and then measuring again after a year. The self-efficacy test is an easy test to administer consisting of only ten questions and taking less than five minutes to complete. Additionally, if new machine learning training is implemented with some population of iMerit's employees, the self-efficacy rates of these employees could be compared with other employees to determine whether or not having this type of additional workplace training is in the company's best interest.

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